C. Cermet Composites for Wear Applications

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Objectives

- Optimize injection molding binder composition and sintering cycles to achieve 99+% density. This will include the determination of the shrink rate during sintering for prototype tool construction and demonstration.
- Test prototype components in intended application on Cummins' fuel system test rigs to show viability of material in an application.

Approach

- Verify properties, microstructure, and shrinkage in test bars manufactured from new source of NiAl powder in injection molded powder composition. Ensure that the properties are the same as for the previous NiAl powder.
- Test prototypes of powder injection molded near net shape components of TiC/Ni_3Al cermet on abuse tests at Cummins Fuel Systems.

Accomplishments

- Found that new source of powder has not compared favorably with the previous source. More work is in progress to define the powder and what steps are needed to improve the strength.
- Did not stabilize prototype component designs during the year, so little progress was made in defining a molding tool for the prototype components.

Future Direction

- Finalize process development for powder using the new source of NiAl powder.
- Evaluate powder injection mold prototype components on abuse test rigs at Cummins.

Introduction

Increasingly stricter diesel engine combustion emission standards and the customer's desire for maintained or improved fuel economy requires fuel injection systems to become more advanced. Injection pressures need to increase (helps with emissions), and more precise control of when and how much fuel is injected (helping both emissions and

fuel economy) is required. New materials that exhibit excellent wear properties against steel components are needed for application where components are sliding and impacting against each other. One material that Cummins is interested in was developed under a DOE Cooperative Agreement DE-FC05-97OR22538: TiC/Ni_3Al.

TiC/Ni_3Al is a composite of TiC powder in a Ni_3Al matrix that was developed in collaboration with Oak Ridge National Laboratory (ORNL) and CoorsTek. Its composition was established to match the unique properties required for Cummins Fuel Systems applications. CoorsTek and ORNL have developed the processing methods to make the material, while Cummins has been responsible to finding an application for it and testing the material as fuel system components and evaluating their performance vs other materials.

Approach

The established composition of TiC/Ni_3Al cermet will be processed using the new source powder and ten powder injection molded components for evaluation of properties. The microstructure, density, and shrinkage rate will be evaluated to determine the suitability of the new powder. Coinciding with this work, fuel systems will refine and finalize the design of some prototype components to be near net shape molded. Following confirmation of the properties and final design, prototype components will be manufactured for rig testing to evaluate the performance and wear resistance of the cermet material in a potential application in the next-generation fuel system at Cummins.

Results

The benchmark strength for the TiC/Ni_3Al powder from pressed and sintered bars is shown below. The initial powder injection molding with the same formulation powder showed a loss of ~10% strength (see below). This was not considered as significant because the debinding process was not optimized for the powder. The powder injection molding with the new NiAl powder showed an additional loss of 15%. This loss was confirmed with tests of the powder pressing and sintering (see below). Evaluation of the test bars showed the presence of NiAl. This may account for the lower strength.

The prototype component design was stabilized, and a final drawing was created for a mold tool to create the powder injection molded components.

Material	Mean strength (ksi)	Standard deviation (ksi)	Coefficient of variation (%)
Baseline (pressed)	152	20.4	13
Injection molded (old)	137	21.5	16
Injection molded (new)	114	5.6	5
Pressed (new)	108	7.0	6

Conclusions

Powder processing is critical to the properties of the material. Additional work is needed to bring the powder properties to the same level as the material using the old source of NiAl powder.

Stabilized design of the prototype is necessary to manufacture the prototype pieces for testing.